Intertoll Trunk Concentrating Equipment

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This article describes the Intertoll Trunk Concentrating Equipment which is a special purpose common-control type switching system. Its function is to combine, at a central point, small groups of trunks serving traffic originating at various outward toll switchboards and to route the combined traffic to a toll or tandem crossbar office in a distant toll center. The operators at the outward toll switchboards are thereby provided with the equivalent of direct access to the intertoll trunk circuits.

Both operating and equipment savings are realized by the use of this concentrating equipment as compared to handling the same traffic via a toll crossbar office at the originating toll center.

INTRODUCTION

This article deals with a method of handling traffic from outward toll switchboards in a metropolitan toll center to a specific distant toll center with the objectives of (1) providing the equivalent of direct access to intertoll circuits from the individual switchboards, for traffic for which direct circuits cannot be justified, (2) giving relief to the No. 4 type toll switching system in the metropolitan toll center, and (3) providing a means for the dispersion of toll switching facilities.

A metropolitan toll center may contain a number of outward toll switchboards. Some of these are situated in the central toll building and others in decentralized locations. An individual outward switchboard may have a sufficient amount of traffic to a specific distant toll center to justify a group of intertoll circuits direct from the switchboard to the No. 4 type toll or crossbar tandem office in the distant center. It has been the practice to provide such direct access to intertoll circuits at centralized toll switchboards. Traffic exceeding the capacity of such intertoll trunk groups is handled over tandem trunks from the toll switchboards via the No. 4 type toll crossbar office in the originating center. The decentralized switchboards in general have reached intertoll cir-

cuits only via tandem trunks to the No. 4 type toll crossbar office in the home toll center.

Handling such traffic through the toll crossbar office involves greater operating effort than handling it by direct trunks since three additional digits per call must be keyed by the operator to direct the call through the toll crossbar office. Also the cost for an intertoll connection is higher with the tandem trunk method than with the direct circuit method, due to the greater number of switching facilities used in establishing the connection. Fig. 1 shows the components used in both cases up to the point where they join common facilities.

INTERTOLL TRUNK CONCENTRATING EQUIPMENT

General

The intertoll trunk concentrating equipment has been developed to provide the equivalent of direct access to intertoll trunks for the traffic, from individual outward toll switchboards, which cannot justify the use of direct trunks. It is a small special purpose common control type switching system located at a central point. It gathers small traffic loads, to a specific destination and automatically routes this traffic to a common group of intertoll trunk circuits which terminate in a toll or tandem crossbar office in the distant toll center.

The maximum capacity of a trunk concentrating equipment is 100 incoming trunks and 40 outgoing trunks. It may be furnished in smaller sizes. If more than 40 outgoing trunks are required to a particular destination, additional concentrating equipments may be furnished.

The field of use for this equipment lies between that of direct trunks and trunks reached through the toll crossbar switching system.

The concentrating equipment is arranged only for multifrequency pulsing from the switchboard. This is a system of pulsing in which combinations of two frequencies within the voice frequency band are transmitted over the talking path to the distant end. Each digit from 0 to 9 employs a different pair of frequencies.

The intertoll trunk concentrating equipment consists of 4 basic circuit components, namely, incoming trunk, trunk selection switches, controller and outgoing trunk circuits.

The detached contact form of circuit presentation is employed in the figures because of its simplicity. In this method the core and winding of a relay may be shown in one location and the associated contacts in other convenient locations. The core and contacts are related by the common designation which appears at the symbols which represent them.

Incoming Trunk Circuits

Several types of incoming trunk circuits are provided to meet the various switchboard conditions where a switchboard and concentrating equipment are located in the same building or to meet the interoffice trunk loop conditions where the switchboard and concentrating equipment are in separate locations. In all cases the incoming trunk circuit receives signals from the switchboard, directly or indirectly and transmits them to the outgoing trunk circuit and to the controller. The incoming trunk circuit also receives signals from the outgoing trunk circuit and transmits them to the switchboard. The incoming trunk circuits, where necessary, also convert the two-wire transmission circuit from the switchboard to a four-wire transmission circuit to meet the intertoll trunk facilities. Fig. 2 shows a typical incoming trunk circuit.

Trunk Selection Switches

The trunk selection switches are the elements which, under the direction of the controller, connect the incoming trunks, requesting service, to the outgoing trunks. Crossbar switches having 20 verticals and 10 horizontals, providing 200 crosspoints, are used. A crosspoint is the intersection of a vertical and a horizontal element of the switch. The incoming trunks are connected to the verticals and the outgoing trunks to the horizontals of the switch. By the switch operation any of the 20 incoming trunks may thus be connected to any of the 10 outgoing trunks.

A single switch will accommodate 20 incoming and 10 outgoing trunks. To increase the number of incoming trunks a similar switch is added for each additional 20 trunks with the verticals connected to the new incoming trunks and the horizontals connected to the corresponding horizontals of the first switch. To increase the number of outgoing trunks switches are added with the horizontals connected to the new group of outgoing trunks and the verticals connected to the corresponding verticals associated with other groups of incoming trunks. The switch arrangement may be envisioned as one large switch having as many verticals as there are incoming trunks and as many horizontals as there are outgoing trunks.

Outgoing Trunk Circuit

Only one type of outgoing trunk circuit is required, as shown in Fig. 3. All outgoing trunks from a particular concentrating equipment terminate in the same distant toll center. The outgoing trunk circuit receives

are made a part of the incoming trunk circuits rather than a part of the less numerous outgoing trunks to which they may be switched. Switching between incoming and outgoing trunks is therefore performed on a four-wire basis.

Controller Circuit

The controller circuit is the control element of the trunk concentrating equipment. Its primary function is to select the incoming and outgoing trunks to be interconnected and to operate the proper select and hold magnets of the associated switches to close the required crosspoint. Since the controller circuit is described in some detail later, only the general principles of it will be dealt with at this time.

The controller divides the incoming trunks into ten groups, (0 to 9), of ten trunks each. When idle it admits calls for a very short interval and then closes gates which exclude all other groups until calls recognized, within the gate, have been served. The controller serves the groups and trunks within the gate in one of two orders depending upon the direction of selection existing at the time. In one case selection will start with the lowest numbered trunk in the lowest numbered group and progress to the highest numbered trunk in the highest numbered group. In the other case the order will be reversed starting with the highest numbered trunk in the highest numbered group and progressing to the lowest numbered trunk in the lowest numbered group

The controller also divides the outgoing trunks into four groups, (0 to 3), of ten. The outgoing trunks are served in order, either from low numbered to high numbered trunks or vice-versa. Once selected, the outgoing trunk remains locked out, after use, until all trunks have been used, or until a trouble condition causes a reversal of the direction of selection of the outgoing trunks.

To avoid connecting an incoming trunk to two outgoing trunks or connecting two incoming trunks to an outgoing trunk the controller tests both the select and hold magnets for possible trouble conditions, such as crosses, before operating them.

Each intertoll trunk concentrating equipment has but one controller. If the controller ceased to function the entire concentrating equipment would be out of service. To insure reliability the philosophy was adopted in the design that no single trouble should disable the controller. This accounts for some of the features, the reasons for which otherwise are not obvious.

Completion of Calls

The basic circuit components of the intertoll trunk concentrating equipment are shown in Fig. 4. Three incoming trunks in different groups and from different switchboards are shown. Two outgoing trunks in different groups are also shown. Assume that the controller is conditioned to serve both incoming and outgoing trunks in the low to high order, that a call is placed on incoming trunk 14 and a short time later on incoming trunk 21, and that outgoing trunks 04 and 36 only are available for selection. Seizure of trunk 14 at the originating switchboard causes the incoming trunk to place a ground on the start lead of incoming trunk group 1. This ground indicates to the controller that a trunk in incoming group 1 is calling for service. The controller then closes the gate to all other ten groups, tests the select magnets associated with horizontal 04 for crosses (since outgoing trunk 04 is first in order for selection) and finding none operates the select magnets. It then tests the hold magnets associated with vertical 14 and finding no crosses operates the hold magnets, thus closing the crosspoint whose coordinates are (04, 14) connecting incoming trunk 14 to outgoing trunk 04. The outgoing trunk transmits a seizure signal over the intertoll facilities to the distant end which then transmits a signal back to incoming trunk 14, which relays the information to the controller. The controller then releases from that connection, opens the gates and admits the call waiting on incoming trunk 21. It proceeds to complete this call to outgoing trunk 36 which is next in order of selection in a similar manner.

If in the assumed case outgoing trunk 36 was the last trunk then available for selection the controller would, at the completion of selection of trunk 36, proceed as follows:

(1) If any of the other outgoing trunks which had been locked out were idle the controller would now make these trunks available for selection.

(2) If no trunks were idle the controller would wait, and cause a signal to be transmitted to all associated outward switchboards. This signal will prevent the lighting of idle trunk indicating lamps at each switchboard. When one or more outgoing trunks become idle the controller will make them available for selection and will permit the idle trunk indicating lamps at the associated switchboards to light as an indication that trunks are available.

Component Circuits of the Controller

In the following paragraphs the component circuits of the controller will be described individually. The descriptions of these circuits contain the minimum of detail required to understand how they function.

"Tens Group" and "Tens Gate" Relays for Incoming Trunks

The incoming trunk associated with each controller are divided into groups of ten. These groups are designated 0, 1, 2, etc. Each trunk in the group has a unit designation 0, 1, 2, etc. which corresponds to the vertical of the switch to which it is connected. For instance, an incoming trunk in group 2 which is connected to the number 3 vertical on the switch is designated 23. Each group of trunks has a common start lead, (ST), (See Fig. 2) to the controller which is grounded when any trunk in the group is calling for service. Each trunk in the group of ten supplies an individual lead US to the controller which is also grounded when the particular trunk is calling for service. This lead serves to identify the units designation of the trunk.

In the controller there is a group of three relays associated with each group of 10 incoming trunks (Fig. 5). These are (1) the TENS relay (TN-) which responds to the ground on the ST lead from the trunk group when a trunk in that group is calling for service providing that the TENS gate is open as discussed below, (2) the UNITS CONTROL relay (UC-) which when operated connects the common group of UNITS relays (U0–U9) to the US leads of the grunk group, (3) the HOLD CONNECT (HC-) which when operated steers the hold magnet operating path to the hold magnets associated with the trunks in the particular group. The UC- and HC- relays do not operate until it is the turn of that associated trunk group to be served.

Two series chains, carried through transfer contacts on all of the TENS relays, control the operation of the UNITS CONTROL and HOLD CONTROL relays. The operation of these relays and the manner of advancing selections from one group to another is best explained by the use of the following example. Assume that incoming trunks in groups 1 and 3 have originated calls resulting in the operation of the TN1 and TN3 relays. Assume also that the controller is conditioned for the low to high direcrion of selection for incoming trunks. When the TN1 and TN3 relays operate, they cause the release of the TENS GATE relays (TG1 and TG2) which close the gates to the operation of any other TN relays and operate the UC1 and HC1 relays. When the UNITS gates close as described later, the TN1 relay is released and the trunks in group 1 will be served. When the last trunk in this group has been served the UC1 and HC1 relays release and the UC3 and HC3 relays operate advancing the selections into group 3. The TN3 and UC3 and HC3 relays then function in the same manner as described for the TN1, UC1 and HC1 relays. If the direction of selection had been from high to low instead of from low to high, group 3 would have been served first instead of group 1.

associated with that incoming trunk is released advancing the selection path to the next incoming trunk to be served. When the last incoming trunk within the gate has been selected the END relay releases, signifying the end of selections in that group and enabling the controller to advance to the next group. The release of the END relay releases the UNITS GATE relay restoring the operating path for all U relays.

Select Magnet Operating Circuit

The select magnet operating circuit is shown in Fig. 7. Two of these circuits are provided in accordance with the philosophy that no single trouble should block the concentrator. One of these circuits is associated with each direction of selection. When the UNITS GATE relay operates as described in the preceding paragraph, battery is connected through the windings of the XS and SS relays, chains on the group relays (GP-), chains on the OT relays, to the select magnet associated with the lowest

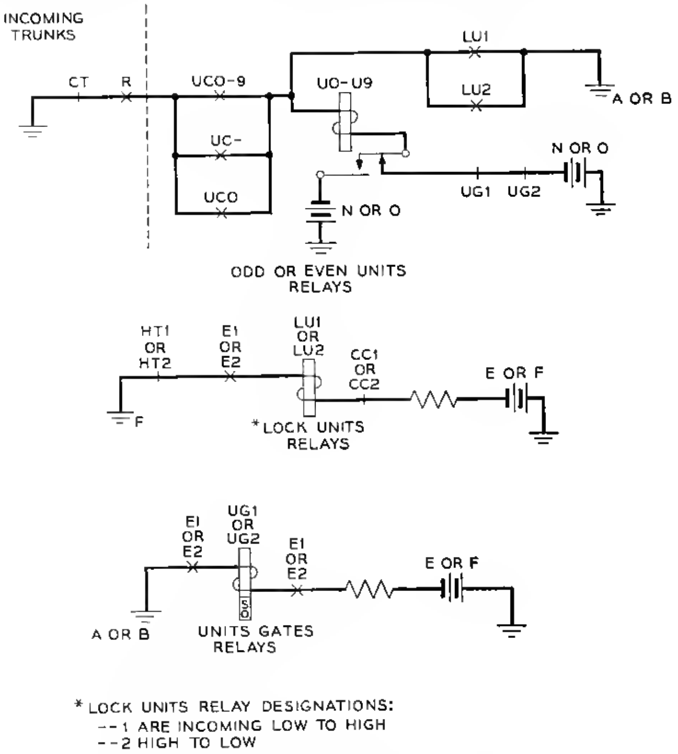

Fig. 6 — Units, unit gates and lock unit relays.

or highest unoperated OT relay in the group depending on the direction of selection. If the path is found to be closed to ground the SS relay will operate. The XS relay is a polar relay. The resistance shown in series with the secondary winding will have a value depeuding upon the number of select magnets which are multipled together on each level of the particular concentrator, which number is a function of the number of incoming trunks. The XS relay will operate on every normal connection since the current in the S winding, which is in the direction to operate the relay, will be larger than that in the primary winding. When the resistance to ground on the select magnet lead is less than it should be, due to a cross with another select magnet lead or to a direct ground, the current in the primary winding will be greater than that in the secondary winding and the resultant ampere turns will be sufficient in the non-operate direction to prevent the operation of the XS relay. This would cause the selection to be halted, the controller to time out and the trouble registered. A reversal in the direction of selection would occur and selections would then be resumed. If no fault is found with the select magnet operating path the select magnets operate. The controller then introduces a small time interval to permit all parts of the selecting bar operated by the select magnet to come to rest. The hold magnet operating path is then closed as discussed below and the crosspoint is closed. The closure of the crosspoint operates a relay OS in the outgoing trunk which in turn releases the select magnets and SS relay which releases the XS relay.

Hold Magnet Operating Circuit

The hold magnet operating circuit is shown in Fig. 8. Two circuits are provided, one for each direction of selection to insure against blocking in case a trouble in this portion of the controller. The cross detection part of this circuit is an unbalanced wheatstone bridge, the galvanometer element of which is the polar relay XH. Three of the arms of the bridge are resistances, the values of which are tailored to each particular concentrator depending upon the number of hold magnets to be encountered on a normal connection. This number is a function of the numher of outgoing trunks. The fourth arm consists of the hold magnets. When the TENS GATES relays released as previously described the XH relay operated (at this time the hold magnets are not connected and the bridge is not formed). Later in the progress of the call, when the UNITS relays operate, the hold magnets are connected and the bridge is formed. If the resistance of the hold magnet arm of the bridge is as expected, the bridge is unbalanced so as to keep current flowing through the XH relay in the direction to maintain it operated. This will permit a relay HT, which furnishes

cessfully completed except as stated above where a continuity check has failed. When the TA relays release, the OT relay associated with the trunk selected, or passed by, is operated and advances the selection to the next idle trunk. The operated OT relay locks to its own GROUP relay GP until the last OT relay in that group has operated. When the last trunk in that group is selected the GP relay of that group is released, advancing the selection path into the next group. The OT relays in the first group are then controlled only from the individual outgoing trunk with which they are associated and will be released when the trunk becomes idle. The trunks in that group cannot be selected again until the group relay has been reoperated which can not occur until all of the outgoing trunks on the concentrator have been selected in turn or until the controller times out. In both of these cases the controller will go through END OF CYCLE operation and reoperate the group relays as later described. With the above arrangement the traffic is spread evenly over the whole group of outgoing trunks.

End of Cycle and Guard Timing

When a connection through the concentrating equipment is released by an operator, the outgoing trunk sends a disconnect signal to the other end, to release the equipment there. It may take approximately 0.75 seconds for the distant equipment to release after it has received the disconnect signal. If this equipment should be reseized before it is released the new call would be connected to the same subscriber. A guard time could be incorporated in every outgoing trunk to prevent the transmission of a seizure signal for this 0.75 seconds, but this would be relatively expensive. To avoid this procedure the end of cycle and guard timing feature has been incorporated in the controller. This feature, shown in Fig. 11, together with the outgoing trunk lock out feature insures that no outgoing trunk can be seized for at least 0.8 of a second after it has been released from a previous call.

When the last available idle outgoing trunk on the concentrator has been selected the last operated group relay GP releases, and two END OF CYCLE relays EC1, EC2 which are normally operated also release. Either one of these relays released operates both the GROUP RESTORE relay GR and an ALL BUSY relay AB. Both the GR and AB relays cause the idle indicating lamp associated with trunks to the concentrator at all originating switchboards to remain dark as an indication that all trunks are busy. If no trunk outgoing from the concentrator is idle at this time nothing else will happen in the controller. When any outgoing trunk in any group becomes idle the GROUP relays associated with such groups

control gap breaks down (which is minimum 63 volts for this tube) R is the value of resistance in ohms, and C is the value of the capacitor in farads. The timing circuits measure an interval of about 0.8 seconds which is sufficient to permit the distant end of any trunk, which has just been released, to restore to normal. When the timing interval is complete the GUARD TIME relays release, the direction of selections is reversed, and selections are resumed.

Direction of Selection Control

Two directions of selection are provided for botb incoming and outgoing trunks to (1) by-pass incoming and out-going trunks which are in trouble, (2) to guard against blocking due to a single trouble in tbe controller itself. (See Fig. 12.) The directions of selection are controlled by two combinations of relays, plus three other relays controlled by these combinations. The AOW and AOZ relays control the outgoing directions of selection. With these relays in the unoperated condition the outgoing trunks will be selected in the low to high order and with them operated selections will be made in the high to low order. The outgoing trunks, in the normal course of events, are served starting with lowest or highest numbered trunks and proceeding to the highest or lowest numbered trunk depending upon the direction of selection at the time. When the last trunk has been selected tbe direction is reversed by either operatiug or releasing the AOW and AOZ relays depending upon the status quo ante. In case a short time-out is due to failure to close the crosspoint the direction of selection of outgoing trunks is reversed immediately. It is also reversed whenever a long time-out occurs, whatever the cause.

The AW and AZ relays form the combination which controls the incoming direction of selection. Controlled by them are the CONTROL relays C1 and C2 associated with tbe low to high and high to low directions respectively. With the AW relay unoperated the C1 relay is operated and the direction of selection is from low to higb. With the AW relay operated the C1 relay is released, the C2 relay is operated and the direction of selection is from high to low. Tbe incoming direction of selection is reversed under the following conditions:

1. When the outgoing direction is reversed upon the last outgoing trunk being selected the incoming direction is also reversed if and when there are no more incoming trunks within the gate waiting to be served.

2. When a short time-out occurs due to the failure of the END relay to operate or failure of continuity check.

3. Wben a second failure to close crosspoint occurs.

4. When a long time-out occurs.

the next idle trunk lights. The lamp does not necessarily move progressively thru the group but is always lighted on the lowest numbered idle trunk in the group.

The direct intertoll trunks and the trunks to a concentrating equip-

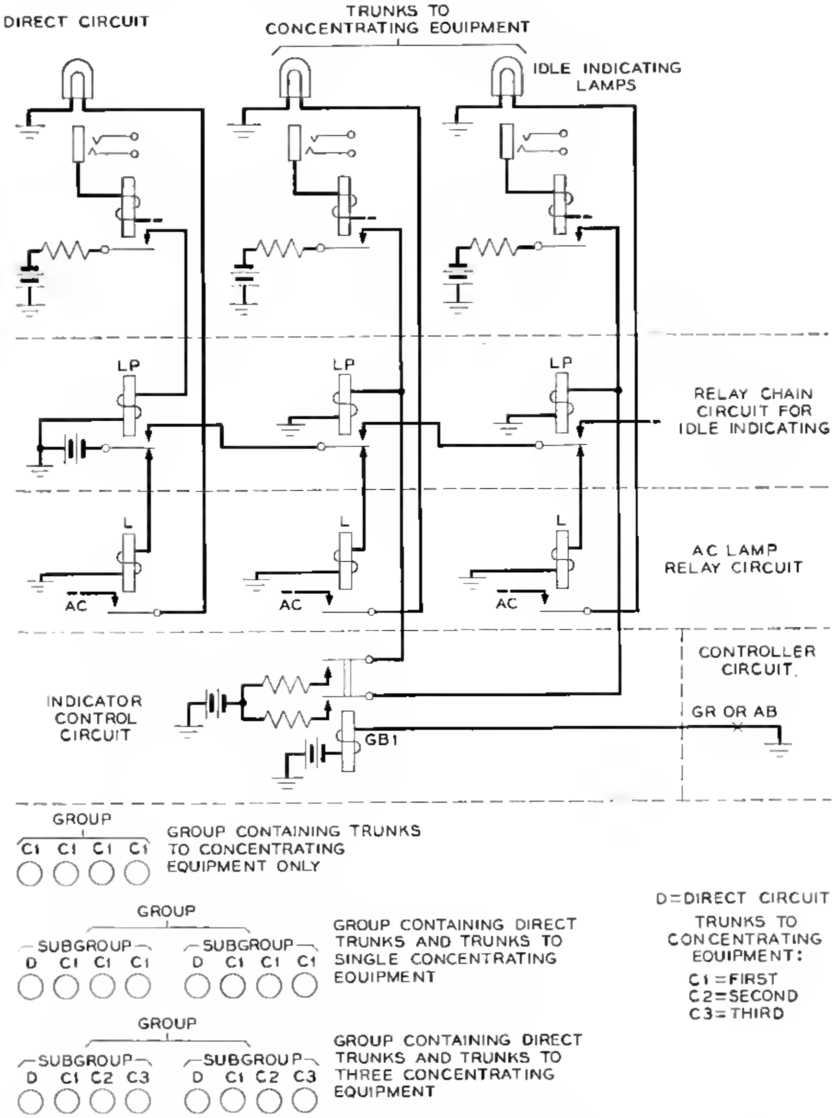

Fig. 13 — Idle trunk indicating control and some examples of groups containing direct trunks and trunks to concentrating equipment.

However, it should be remembered that it contains a single controller which could be disabled by compound trouble, a condition which could be serious if the concentrating equipment were the sole means of handling traffic from any switchboard. It is intended that the concentrating equipment be used in conjunction with direct intertoll circuits and/or tandem trunks to a No. 4 type toll crossbar switching system. When used with direct circuits an operator alternate routing system ensues. Referring back to the paragraph which dealt with idle trunk indicating, it is noted that the direct trunks and the concentrator trunks form a single group or subgroup of trunks to a common destination. The direct trunks appear in the multiple at the head end of the group and are followed by concentrator trunks. The idle indicating lamps direct the operator to a direct trunk, when available, as first choice, and automatically direct the operator to a concentrator trunk when the direct trunks are in use. If the operator also has access to trunks to the toll crossbar office these trunks become third choice for use when the direct and concentrator trunks are busy. Fig. 14 illustrates this situation. The concentrating equipment may be located apart from the central toll building without losing the advantages of the alternate routing discussed above. Thus it is available for dispersing the toll plant to minimize the effect of disaster.

ACKNOWLEDGMENT

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